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TECHNICAL AND ECONOMIC FACTORS IN THE CHOICE OF STEEL PLANT LOCATION

by

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1) A competitive primary iron and steel industry in any country is a national asset that can provide the basis for the establishment of a broader secondary manufacturing industry and stimulus for growth in many sectors of the country's economy. In less-developed countries and areas of any industrialized country where there is no primary iron and steel industry, or where the existing industry is too limited in scope to be a motivating force for economic growth, there may exist sufficiently favourable conditions to warrant considering its establishment or expansion.

2) In this paper an attempt is made to outline general and specific considerations that should be borne in mind when an appraisal is made of the feasibility of establishing, expanding or diversifying a primary iron and steel facility. While admitting that government should play an important supporting role, the technical and economic factors reviewed here are those which a company engaged in commercially profitable enterprises would employ in its analyses. Factors that have affected the establishment and development of the Canadian iron and steel industry are reviewed.

General Discussion

3) The prime motivating force in establishing a steel industry may be economic, social or political. In most countries, all three factors are important to some degree and affect the final decision. No matter what the motivating force may be and what the political-industrial relations within an area or country may be, the prime objective in establishing a steel industry should be to provide primary and secondary products at lower prices than those currently available. On this basis alone it would be difficult to justify some plants being considered or already in existence throughout the world. Moderately higher price levels are tolerable, however, when the establishment of a steel industry is considered within a broader plant of economic development by which, in

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time, a sufficiently large integrated industry can evolve that would achieve economies because of scale of operations. Under such conditions government policy could promote establishment of a steel plant by such techniques as selective tariffs or by the more positive techniques of tax incentives and bounties.

4) Before proceeding with plans to initiate a steel industry or expansion of an existing one, considerable study should be given to determine the size, nature and location of present and possible steel consumption within a given area in relation to the size and nature of the steel plant to be erected and the raw materials to be assembled. In most instances it will be found that no market is sufficiently large to justify a policy of self-sufficiency in the production of every shape, size and grade of steel products consumed or required. A small plant making a limited range of products may be all that is originally justified. Thus, a continual appraisal of the steel-product market in conjunction with a policy of encouraging development of steel-consuming industries is desirable. A flexible tariff schedule and tax incentive program are necessary to obtain the earliest possible end-results. A tariff increase may be necessary to promote new industry. On the other hand, and equally important, a decrease in tariffs should be considered when the industry matures in order to make steel products available at the lowest possible price. It should still be sufficient to enable repayment of capital costs and investment in new plant and equipment.

5) The attitude and ability of both management and labor are of major importance when anticipating a successful industry. In all instances, it will be preferable to initially employ top management and experienced operators from established steel areas. It will be necessary to train and educate both indigenous management and labor not only technically but generally in order to build a populace that is better able to cope with industrialization problems.

6) When considering steel plant location, it is the authors' belief that one must take a broad approach to the problem by determining the size, nature and location of the present and future market for primary steel shapes and for secondary products made primarily of steel. Such an approach is realistic in that emphasis is placed on markets rather than upon resources or other factors. Although resources are important, a domestic self-sufficiency in raw materials used in a primary steel industry is not necessarily a prerequisite to starting a primary iron and steel industry.

7) Although costs of labor, raw materials at the source, power, land and other items are important, the cost differentials of these facotrs in assessing steel plant location within a large region are small compared to differentials in transport costs of raw materials and finished steel products. During the eighteenth and most of the nineteenth centuries, the number of tons of coal required per ton of iron and steel produced compared with ore requirements and steel-product shipments to market overwhelmingly favored steel plant locations near coal-producing regions. The locational dominance of coal has dwindled when considering locations for new steel plants because of major advances in technology generally and particularly in fuel economy. By the end of the nineteenth century, the locational pull of ore had, in a few instances, become significant in relation to the tons of coal required. To-day, the amount of ore required generally exceeds that of coal by a significant margin. Another important reason for the decline of coal's dominance in steel plant location is the ready availability of scrap in many parts of the world. By the end of the nineteenth century, scrap consumption had become of major importance in reducing the requirements of iron ore and, consequently, coal per ton of steel produced. Because of the lower amounts of ore and coal required

and the increasing amounts of scrap used per ton of steel produced, the attraction of a market-oriented location has increased. Trends to beneficiated and higher grade natural ores resulting in lower transport costs and additional fuel economies; the availability of scrap; coal savings through the use of supplementary fuels; and a large differential between transport costs of raw materials and steel products together have all resulted in a relative increase in the significance of markets rather than raw materials as the dominant locational factor for steel plants.

8) During the last decade, another set of conditions has resulted in the emergence of coastal locations for steel plants, particularly in more industrialized countries where domestic supplies of ore are low grade and coal costs are relatively high. In such circumstances coastal works can take advantage of the abundant supply of high-grade ores now available from many world sources and the availability of high-quality coking coals, mostly from North America, to replace or supplement domestic coal supplies.

9) In the future, as the need for greater amounts of iron in the form of ore or scrap increases and the availability of economic domestic energy and reductant resources decrease, it is conceivable that a gradual trend may be established wherein industrial nations may import iron and energy together in the form of such products as pig iron, sponge iron and even crude steel. This trend would work to the advantage of less-developed nations. Many such nations, with growing steel requirements but lacking one or more of the basic raw materials for steel manufacture, have access to world supplies as readily as have industrialized nations. In addition, technical changes in making pig iron and steel have progressed to where alternatives to the blast furnace pig iron process might be considered. Such alternatives can be based on domestic sources of natural gas, fuel oil or electricity rather than on coke made from imported coal. Because of present and anticipated greater economies in large, integrated blast furnace-steel furnace facilities, application of new reduction processes will probably be limited to small market areas relatively distant from integrated steelworks, or for special applications.

10) Because of the large capital investment required for new steel facilities it might be prudent to compare the benefits resulting from alternative capital investment. Economic theories suggest several methods by which the effect of the establishment of a steel industry on an area can be estimated. It has been established that the multiplier effect in related secondary and service industries and the economy at large is greater from the establishment of a steel plant than from the establishment of most other primary industries. Simple "comparative-cost" studies, unfortunately do not provide a comprehensive picture of the total effect on an economy from investment in any particular industry, especially its effect on secondary employment.

11) Ideally, an 'input-output' analysis could be used to determine the impact of a new industry on a region's economy. However, the detailed information required to make such an analysis is rarely available. Theoretical and practical difficulties arise from the use of coefficients obtained from a study of an economic situation existing before the erection of a steel plant if they are used to estimate conditions that would prevail afterwards.

12) A more feasible and practical method would appear to be the 'industrial-complex' approach. In this analysis, an assumption is made of other principal industries that would likely be formed or expanded as the result of establishing a primary iron and steel plant. The decision to invest in primary steelmaking facilities would then depend on

whether the benefit resulting from the complex is greater than it would be for investment in other industries.

Markets

13) In the development of a general program, the authors contend that prime consideration on building a steel plant should be placed on a detailed analysis of steel-product consumption after a preliminary analysis indicates that economic iron and steel production is within the range of economic feasibility. Investment funds necessary for an iron and steel industry are large and even though an iron and steel industry is usually the basis for general industrial growth a comprehensive statistical and market analysis is vital to the economic feasibility appraisal. The consumption pattern of iron and steel products within the country or geographical region under consideration should be determined in detail. In some instances it may prove desirable for two or more countries to cooperate in a market study with a view to establishing a joint steel complex to serve an enlarged market area. The statistical information on steel-product consumption should be gathered and tabulated by region, industry, shape, size and kind. Present sources of primary steel shapes should be noted. In cooperation with consumers, it may be possible to reduce in number the different shapes and sizes that are required. This could be of benefit by lowering capital outlay for equipment, depreciation and capital writeoffs and general operating costs.

14) During the planning of an industrial-growth program, consideration should also be given to the expansion and diversification of secondary manufacturing industries. The type and quantity of steel required for such planned growth should be estimated and incorporated into the projected market pattern. The evolved pattern should also have regard to population growth, possible population shifts and anticipated per capital income as these factors usually reflect changes in total steel required, product mix, general purchasing power and transportation costs of steel products to the market. In a more general context, present and potential levels of gross national product, national income, balance of payments position and similar factors should be considered to establish the best methods of financing, the rate at which investment capital can be repaid and the amount of capital that can be realistically invested in a new steel plant, or in the expansion of an existing one.

Rolling Mills

15) Based on present and projected steel consumption, by kind, the extent of established and possible markets can be resolved into categories that reflect the range of products that can be produced on various types and sizes of rolling mills. It will become evident that some categories of steel products will not be sufficiently important to warrant installation of a mill to produce those products. Any mill should operate regularly and process enough crude steel to warrant the capital expenditure; idle equipment and invested capital raises production costs of all items. Thus, imports of certain steel shapes such as larger structurals, wide sheet, coated sheet and heavier plate will probably be necessary until such time as the domestic market is sufficiently large to justify additional mill installations for their production. Also, it may be some time before the market for specialty steels (stainless, high alloy, tool steel, etc.) is important enough to warrant consideration. Later in a location study, one must return to the market pattern to determine if some shapes are available elsewhere at a significantly lower price to warrant continuing imports even if a minimum-size total market is available to support a domestic

mill. From such data, one or more mills can be selected to give the maximum benefit in terms of return on capital, more stable employment and lower-cost steel products to the domestic consumer. Advantages should be taken of improvements in steel rolling mill practice and technology. Continuous casting has been sufficiently developed to warrant consideration of its use. This technique can bypass the steel ingot, soaking pit and blooming mill stages and achieve considerable savings in capital investment and operating costs. Combination rolling mills such as bar and strip, rail and beam, bloom and plate, etc. may also be installed to advantage to achieve cost economies.

Steel Technology

16) Once the nature and extent of the steel product market to be supplied has been determined and decisions made on the number, type, size and complexity of the steel rolling mills that might economically be installed, consideration should then be given to the kind of ironmaking and steelmaking facilities that will supply crude steel to the rolling mills. In most instances, iron and steel facilities will be built adjacent to the rolling mill section of a plant to achieve maximum economies on items such as transportation, handling, energy management and quality control. In some instances, it may prove desirable to establish a non-integrated mill closer to a specific market area that is distant from an integrated complex centrally located to serve a widespread and large market. Facilities that might be built to make crude steel can vary considerably A small, electric steel furnace plant that is based entirely on scrap as a raw material would probably be sufficient to supply limited quantities of steel for products such as reinforcing bars and other merchant mill products. It is difficult to make steel of sufficient quality to produce acceptable flat rolled products by melting scrap in electric furnaces. It may prove desirable to establish rolling facilities and import such primary steel shapes as ingots, blooms billets and slabs rather than determinedly build complete facilities. For large-scale production, the blast furnace for ironmaking and the open hearth or basic oxygen process for steelmaking will usually be the most economically feasible processes to employ. On an intermediate scale of output, electric furnace ironmaking may find a place if hydroelectric power is available at low cost. Processes to produce a sponge iron or reduced iron for steel furnace charging may prove more economical and practical than blast furnace or electric furnace pig iron, especially if low-cost fuel oil, natural gas or non-coking coal are readily available.

Raw Materials

17) Simultaneously, the analyst should consider the source of iron ore and other basic raw materials, the quality and supply of scrap, and energy sources that might be available before the best location for iron- and steel-making facilities can be properly assessed. The domestic raw material resources of an area or country should be reviewed For present producing areas, the quality of the products shipped and their costs would be known. Resources not yet being mined should be evaluated not only in terms of total cost of production but also with respect to quality, variations in quality, available reserves and, if necessary, beneficiation characteristics. Consideration should be given to the adequacy of installed transportation facilities. For the movement of most bulk commodities such as iron ore, coal and limestone, rail and/or water facilities would be reviewed to determine the less costly. In some instances, particularly for steel products, road transport may be the least expensive means. Transport costs are of prime importance in considering steel plant location. A detailed assessment of costs for moving materials to and from the steelworks is necessary to determine the most 'economic' plant location.

Analysis

18) With required data on resources, transport and markets, the analyst working in conjunction with a team of specialists (ore dressers, metallurgists, design engineers, etc.) would select several alternative locations on which total cost of steel ingot production costs could be determined. One or more locations would likely be considered for each of the following general areas - coast, inland near market, and inland near major resource(s). For coastal works or those on inland navigable waterways, major factors to consider are: proximity to market, adequacy of transport to inland market and suitability of harbor for boat movements, docking, etc. It is important to note that all or a portion of raw materials might be imported to advantage by lowering costs of production. Exports could then be in the form of raw materials if excess production to needs is developed, pig iron, crude steel, rolling mill products and, conceivably, secondary manufactures. An inland works near the major market area should be on present or projected transport facilities. A weighted minimum transport cost for all steel shipments can be estimated if transport costs and the amounts of steel that will go to all markets are evaluated.

19) For each hypothetical location, the quality and cost of raw materials can be assessed to determine the most economic processing equipment that might be installed to supply steel ingots for the proposed steel rolling operation. The most suitable raw material mix from domestic and foreign sources would also be determined. When the costs of rolling the various steel products at each hypothetical plant location have been estimated, comparative cost studies of weighted transport costs for steel products to the market can be made. From these, the most economical location for a steel plant can be selected. Other less important factors that, in particular instances, may be critical are water supply, labor supply, labor cost differentials, local taxes and by-laws. Having agreed upon the most desirable steel plant location the estimated cost of steel products in the main markets, a comparison of present prices paid for these products from other sources, domestic or foreign, will determine which products can be supplied more economically to the ores from a new or expanded plant and the severity of competition that will be encountered.

20) If tax incentives, national policy, subsidy and related factors are not considered, steel plant location is then very closely related to the nature of the market that can be served and the anticipated competition in that market. The market governs the amount, size, and type of steel products that can be produced competitively and this, in turn, influences the size and type of iron and steel-making facilities that might be built. The kind of iron and steel to be employed is also dependent upon the cost and quality of the raw materials available.

21) If, as a matter of national policy, it is considered desirable to have an iron and steel industry, the analysis at this point would afford a means of determining the cost to the country of establishing a protected industry. Excess cost, in the form of high prices for domestically-produced products, may rule out further consideration of a domestic industry under existing circumstances.

Development of the Canadian Steel Industry

22) Since its origin in the latter part of the nineteenth century, the Canadian iron and steel industry has been confronted with many problems of development. The industry's success, particularly during the last two decades, has been responsible in considerable part for Canada's status as an industrial nation and for the relatively high standard of living prevalent in Canada. When considering the industry it should be regarded as several separate companies competitively pursuing a common profit motive rather than as a single body centrally regulated with respect to markets, prices, investment, etc. This is not to say, however, that the companies constituting the Canadian iron and steel industry disregard their social and national economic obligations. Government help and influence in the form of subsidies, taxes, tariffs, legislation and moral suasion, have aided in its establishment and growth.

23) As in many countries up to the 1880's, there were several small iron forges in Canada. Between 1850 and 1880, several non-integrated rolling mills were constructed whose operations were based originally on scrap and iron, and later in part by imported crude steel. In 1879, as part of the federal government's National Policy, a decision was made to encourage domestic iron and steel production through the establishment of duties on imports of steel items made in Canada. In addition, a bounty system was in effect between 1883 and 1910 on the production of pig iron and steel. On the municipal level, tax incentives were offered to new industry. This action gave impetus to various commercial interests as well as to domestic and foreign entrepreneurs to consider the feasibility of establishing primary iron- and steel-making facilities to supply a portion of the steel market. As a result, between 1895 and 1905, blast furnaces were erected at three of the four locations where integrated steel works presently exist.

24) The Nova Scotia plant was located on tidewater near a coal source. Ore and limestone were imported from captive mines on tidewater in Newfoundland, then not part of Canada. The Nova Scotia plant was well located with respect to ocean and inland water routes and to eastern Canadian rail facilities. At Hamilton, Ontario, a plant was established to utilize domestic ores but it soon proved more attractive to import ore from the United States via inland waterways. Coal was imported from the United States for all Ontario blast furnaces, even though domestic sources existed in eastern Canada. The Hamilton plant was strategically located with respect to markets and rail and inland water transport. The third plant built during this period was well located with respect to a captive ore supply and nearby sources in the United States. Coal from the United States required a long rail and water haul. This plant was further from the main concentrated market in southern Ontario but was in a better position to supply the railway system and expanding agricultural areas in the west. The fourth integrated plant became established, as such, in 1951 at Hamilton. It was based on imported coal and ore and serves the most concentrated market area in Canada. It grew out of a foundry operation established in 1913 and which, through a series of company purchases and amalgamations, had become a substantial producer of electric furnace steel, based on purchased pig iron and scrap, and rolling mill products. Besides the four integrated works, two of the integrated companies also operate steel rolling mills closer to specific markets. It should also be mentioned that during the industry's formative years, several other companies made attempts to establish iron and steel plants but, for various technical and economic reasons, they failed. Financing of the industry during the early years was largely through bonds sold in England although some capital was obtained in the United States. There was no dearth of technical and commercial ability in Canada but it was felt expedient to bring some

highly qualified personnel to Canada to manage, advise and work in some of the plants. This practise exists even today, particularly with respect to highly-trained management and technical persons.

25) From 1900 to 1920, the industry prospered by producing wire for fences and nails, merchant mill products and products for the railway industry. World War I provided the impetus to increase production and diversify the product mix.

26) Between 1920 and 1939, the industry was static in terms of increased production, diversification, significant new facilities, markets and financial stability. By the beginning of World War II, however, the industry was sufficiently sound to enable considerable expansion in production facilities and product mix. Since World War II, the industry, in concert with an unprecedented growth in the Canadian secondary manufacturing industry, expanded production facilities and diversified to the extent where Canada is self-sufficient in nearly all steel products. This is due, primarily, to growth in population and national income sufficiently large to justify investing in necessary plant and equipment. All steel companies have not expanded or modernized equally because of variations in such factors as proximity to the area in which market growth has been most significant, availability of capital, changed raw material costs, management, etc.

27) In recent years, considerable interest has been shown concerning the feasibility of new integrated facilities in western Canada and Quebec. Consideration has been given not only to traditional processes but also to other ore reduction processes in various stages of technical development based on electricity, fuel oil, natural gas or non-coking coal. In western Canada, extensive reserves of oil and natural gas were discovered in the 1950's that not only provide a relatively inexpensive energy source but also an expanded oil and gas industry market for steel products. Coking coals have also been defined there and limestone is in good supply. Well-located iron ores of suitable quality are not readily available but low energy costs could offset this disadvantage. The main problem, however, is defining sufficient markets to justify establishment of an integrated industry. In Quebec, a location along the upper St. Lawrence River is well suited to the assembly of raw materials. The main problem here is also to define the market closely and to determine what portion would be satisfied from a local plant in competition with existing integrated plants in Ontario and Nova Scotia and from electric-furnace plants in Quebec's main market area. Consideration is also warranted on the various alternate processes to the blast furnace for iron production if the market is not large enough to justify building a traditional blast-furnace plant. In fact, the electric furnace 'direct-reduction' process is now used to produce pig iron of different grades in Quebec and British Columbia. In the former, iron is a coproduct with titanium-dioxide slag and in the latter it is made from iron oxide calcine that is a byproduct of non-ferrous mining and concentration operations. At present, several provincial governments in concert with industry are evaluating various other possibilities.

28) It is difficult to determine what part protection by tariffs and aid by bounties have played in the establishment and development of the Canadian steel industry. The decision to encourage a domestic steel industry was part of the 'National Policy of 1879' when the iron and steel industry received important new protection with duties on rolled and forged steel items that ranged up to 20 per cent. Steel ingots were admitted free until they could be made in volume in Canada and in 1883 they were subject to a specific duty. In that year a federal bounty was established on pig iron produced from domestic ore; this was extended in 1894 to Canadian-produced steel and in 1897 to pig iron made

from foreign ore. Federal bounties with various changes continued in effect until December 31, 1910, when all bounty payments were withdrawn. Moderate tariff protection is still accorded the Canadian iron and steel industry. Items not made in Canada enter duty-free or at very low rates; items made in Canada are dutiable to an extent that depends upon domestic production capacity, markets and other considerations. The domestic industry owed its establishment, in large part, to federal and provincial bounties on pig iron and steel; the existence of tariffs on imported steel products, and the granting of certain municipal incentives. The only remaining bounty is that paid by British Columbia for a limited amount of pig iron production. Notwithstanding the aid provided the early industry by bounties and tariffs, all the present pig iron and steel plants in Canada have been built and have grown because of fundamental economic and technical conditions rather than because of a national policy of protection to the industry. Its production capacity today of about 8 million tons of ingots a year, placing it 12th among world producers, is based primarily on the industry's ability to compete with other highly industrialized nations both with respect to quality and cost of steel rolling mill products. It is of interest to note that the Canadian industry depends in large measure on imported raw materials.

29) In conclusion, the Canadian iron and steel industry has grown and diversified at a very satisfactory rate in spite of the country's location adjacent to the very large, highly-industrialized economy of the United States to the south. This growth, based to a large degree on imported raw materials, has been achieved on the basis of private enterprise initiative with the government role being of a secondary or supporting nature except in the area of tariffs. The main stimulant to location and growth has been markets rather than resources, even though Canada is rich in the raw materials for steelmaking. The presence of water, rail and land transport facilities for the assemblage of raw materials and distribution of steel products is of the utmost importance.

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